REMARKS

Applicant's remarks of the June 5 amendment paper are incorporated by reference as if put forth herein in full. This supplemental amendment is in response to the Office Action dated January 2, 2001, and is further to the amendment (June 5 amendment paper) already filed.

The present technology is new. Thereby, applicant believes that the Examiner has not fully and properly understood the present invention, nor fully understood the invention of the Schwarte reference (DE 197 04 496 and WO 98/10255 from which Australia 715 284 originates), which reference is also the invention of the present applicant, Professor Schwarte. The applicant, Professor Schwarte, is well published and well respected in his field.

A photomixing device ("photonic mixing device") addressed in the present application is a completely new electronic device, or more specifically, optoelectronic device. The functionality (operation) of the present invention is new to the rest of the world. Professor Schwarte's prior German and Australian patents (the reference DE 197 04 496) also address this new technology, which other than that does not have any predecessor in the art, and is far from being just a new type of a photodiode. There was no photonic mixing device, whatsoever, disclosed in the art before the above-cited Schwarte reference.

The present invention is an improvement to the previous Schwarte photonic mixing device.

However, this improvement cannot be learned or derived by combining technology from ordinary photodiodes, because the individual elements of a photonic mixer device serve a completely different purpose, and are operated according to a completely different algorithm than ordinary photodiodes.

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This is likewise the situation for physically similar structures, in previously known photodiodes, or more generally speaking photosensitive electronic elements (such as CCDs etc.). These other structures cannot be carried into a photonic mixing device and then be expected to operate for the purposes of a photonic mixing device. There can be no operative combination.

It is the purpose of an ordinary prior art photosensitive device to detect the light impinging on that device by generating electrical charges thereby providing a "photo-effect", i.e., collecting and storing the electrical charges, wherein the amount of charge corresponds to the amount of light which impinged on a corresponding area (pixel). This function of determining the amount of light impinging on a pixel area is not the design purpose of a photonic mixing device, even though such photodiode data may be obtained after further engineering as a by-product of the operation of a photonic mixing device.

Contrary to a photodiode device, within a photonic mixer the modulation of the impinging light is mixed with the electronic modulation of gates resulting in the effect that the difference of the gate currents generated by the charges occurring at the accumulation gates yields a "correlation function", which by no means includes any information about the intensity or amount of light impinging on the pixel, but instead, provides depth/ distance information about the object from which the light originates. This requires that there be a well-defined correlation between the modulation of the impinging light (as reflected by an object) and the electric modulation of the gates.

Having acquired this data, it is of course also possible to later generate the sum of the signals, which corresponds to the intensity of all light impinging on a pixel, while the difference provides reasonable information only from the modulated part of the light. Therefore, the algorithm for the present invention, a photomixing device, measures a "difference" and mixes it

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with the modulation of the gat s. The algorithm for a photodiode measures a "sum" without any modulation consideration.

Accordingly and in contrast to ordinary photosensitive devices, the charge occurring at the accumulation gates of the present invention is not collected for times in the order of several ten or hundreds of microseconds or even milliseconds, but instead, due to the modulation which is the MHz or even GHz range, the accumulation gates are continuously read out, in order to obtain the difference in currents from the accumulation gates associated to the respective modulation gates. In other words, a photonic mixer is a "signal processing device" rather than a "measuring device" (that being a photodiode device).

Accordingly, with such a new technique there appear new problems, which never occurred with any of the prior art photosensitive devices. In particular, these problems arise due to the modulation, which is required for a photonic mixing device, but is not desired for a prior art photosensor (photodiode).

As may be understood for instance from figure 1 of the present invention, and even better from figure 6 of the prior art Schwarte reference, the modulation causes a potential drop between the modulation gate and the accumulation gates. This potential drop (shown as step function in the two aforementioned figures) causes a drift of the charge carriers (i.e. electrons or holes) toward one of said accumulation gates, depending on the actual direction of the potential drop. Because the potential changes its direction (change between "d" and "f" in figure 1, or between state "b" and "c" in figure 6 of Schwarte) within a very short period of time in the order of nanoseconds or maybe even less, it is crucial that a sufficient amount of charge carriers (in the following denoted as electrons) can be moved towards the respective accumulation gate, in order that any difference between the amounts at the two accumulation gates can be detected at all.

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Applicant has now found that the yield of electrons occurring at the respective accumulation gate, or better to say the difference in the amount of electrons occurring at the two accumulation gates on a very short time scale, can be greatly improved if the respective gates are formed in the shape of long narrow strips. While the above principal figures may be found in the above mentioned prior art Schwarte reference, Schwarte at that time was not concerned with, nor did he address the actual shape of his gates except for the provision of square gates having four modulation gates with phase differences of 90° arranged at a center accumulation gate, such as for instance shown in figure 9 of the Schwarte reference.

However, when considering for instance figure 6 of the Schwarte reference, and assuming that G_{am}, G_o and Gb_{bm} are rather wide, it is clear that in the state as shown under b) that the distance from G_{bm} to G_a is correspondingly large as well as in the state c) the distance from G_{am} to G_b. However, what appears to be even more important is that it is clear that along the width of the actual gates G_{am}, G_o and G_{bm}, the respective potential is substantially constant while a substantial potential drop only occurs at the transition from one gate to the next. Specifically, the actual acceleration of the electrons towards the respective accumulation gates only occurs where potential drop is visible. In the Schwarte reference, this resulted in average drift times in the order of tens and up to hundreds of nanoseconds. Wherein with the shape of narrow strips of the present invention, these drift times may be reduced to well below 1 ns. These short-time responses are of no significance for and are not a consideration of prior art photosensor devices. Therefore, one of ordinary skill in the art would not consider adopting the structure of a photosensor (photodiode) device to solve the Schwarte reference shortcomings.

Of course, in order to have a sufficient amount of electrons generated, the total surface of a pixel must still be in an order of magnitude which is not too far from ordinary pixel area of that disclosed in the previous Schwarte reference. This is the reason why the applicant discloses that the gates should not simply be made smaller and arranged closer together but

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should be formed in the shape of long narrow strips resulting in an overall surface which is sufficient to generate a measurable amount of electrons by the impinging light, but still the drift time towards the accumulation gates can be substantially reduced so that the respective modulation frequencies can be increased, thereby substantially increasing the band width of the modulation signals. This in turn improves the depth/ distance resolution obtained via the "correlation function".

Considering the above discussion and explanation, it should be obvious that there are no corresponding problems and thus no corresponding solution thereof anywhere in the field of photosensitive measuring devices. The charge collecting times with CCD devices are by orders of magnitudes larger than the drift times of the electrons which are relevant for the photonic mixing elements. Therefore the shape of pixel elements or the electrodes thereof are not crucial for an ordinary photosensitive device, such as a CCD. Moreover, once this information becomes known, one of ordinary skill in the art would not transferring technology from photosensor devices to photonic mixing devices.

Applicant believes that the cited reference of Lambeth (US 4,826,312) is absolutely not pertinent for the present invention. Starting with the photonic mixing element as previously disclosed by the Schwarte reference, there is absolutely not suggestion anywhere in the prior art, that for photonic mixing elements in the form of long narrow strips might be desirable. Moreover, the use of long narrow strips in photosensors does not affect drift times.

Lambeth is dealing with a completely different problem. The main purpose of the disclosure by Lambeth is the one-dimensional resolution of the strip diode for detecting the apparent location of a spot in a scene imaged onto the sensor. This improves the overall performance of the range finder device in which the stripe geometry diode is used (see the abstract of US 4,826,312)

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In as far as Lambeth is also dealing with the measurement of distances (such as shown with figure 3 of the prior art referred to in Lambeth), there should be noted that the Lambeth measuring algorithm is completely different from, and inconsistent with, the photonic mixing element algorithm. Lambeth distance measurement is simply triangulation and imaging of objects under different angles on different locations of a chip. This has nothing to do with photonic mixing, but is simply a reduction in scale of the pixel size, at least along one direction in order to improve the resolution for triangulation.

However, improving the statial (horizontal) resolution is not the purpose of the strip structure for the present photonic mixer. Instead it is desired in the present invention that the bandwidth of modulated signals processed by a photonic mixer is increased.

In summary, a skilled person, once having understood the principle of photonic mixing device as disclosed by the Schwarte reference, would never consider a document such as Lambeth, as Lambeth deals with a completely different problem for a completely different purpose with the geometrical structure of a CCD device.

Having reviewed the principal differences between a photosensitive device according to the prior art and the photonic mixer of the present invention (which measures distances and depth structures instead of images), claims 1 and 2 are being amended herein to more clearly recite those differences.

Claim 1, as amended herein, has deleted the restriction to the optical and near infrared and ultraviolet ranges. From the above description of the respective technologies, it is clear that all which is required for a photonic mixer is a material sensitive to electromagnetic radiation by generating charge carriers (electrons or holes) once the radiation impinges on the sensitive material. It is obvious that there is no need to restrict the range to the optical and near infrared and ultraviolet ranges, because it simply depends on the actual (semiconductor) material whether or not charge carriers are generated due to the by impinging radiation.

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Further, in line 5 of claim 1, there occurred an obvious error due to a possibly misleading portion in the translation of the original claim 1. As may be seen from the drawings (figure 4 and figure 5), the accumulation gates are shown in black while carrier-generating radiation is only shown there between. This means that the respective accumulation gates are either formed of a material which is not photosensitive or, if this material is photosensitive, then these areas should be shaded, i.e. covered by a non-transparent material. This is due to the fact that the measurements of the differences between electrons shifted to the left accumulation gate or the right accumulation gate should not be obscured by additional electrons generated by light directly impinging on the accumulation gates. Therefore, these gates are either of non-photosensitive material, or if of photosensitive material are then shaded to render it non-photosensitive.

Accordingly, the words "nor shaded" are deleted from claim 1; and the word "neither" is amended to recite "not" (not photosensitive), so that claim 1 now recites that the accumulation gates (4,5) are not photosensitive. Claim 3 is amended to recite that if the accumulation gates (4,5) are photosensitive they are shaded.

Referring to the last line of the claim 1, which recites that the cathode should be a reading-out electrode, this is again just due to the fact that in the most common photosensitive materials the electrons are the charge carriers which are displaying a better mobility than the holes which are simultaneously generated by impinging light once an electron is generated as a free charge carrier. Because the electrons are moving towards a cathode quicker than the holes would move towards the anode, the cathode acts as a reading-out electrode. In such a situation, this condition contributes (even though only slightly) to further improve the bandwidth and the range of possible modulation frequencies. On the other hand, there may be reasons, in particular outside the preferred ranges of the spectrum, where other semiconductor materials are used such as GaAs, in which in fact the holes might have the better mobility and in that case

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the anode might preferably be used as a reading-out electrode. Accordingly, the phrase reciting that the cathode of each diode is a reading out electrode has been deleted to no longer recite that restriction.

Claim 2 is no longer an independent claim, but has been amended to depend from the newly recited limitations of claim 1.

In view of the remarks in the previously filed amendment (June 5 amendment paper), and the above-recited reasons, it urged that the claims and specification now overcome the standing objections, the standing Section 112 rejections, and the standing rejections on art under Sections 102 and 103.

Applicant wishes to thank the Examiner for the telephone interview with his attorney regarding the transmission for consideration of this supplemental amendment.

The claims as now amended distinguish the present invention over the cited prior art. It is respectfully requested that the application be re-examined and be passed to issue with these claims.

Respectfully submitted,
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